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Resistance of the Vineland Series of Apple Rootstocks to Fire Blight Caused by *Erwinia amylovora*

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Abstract

The fire blight resistance of several *Malus* rootstocks (V.1, V.2, V.3, V.4, V.5, V.6, V.7, and VR.50 in the Vineland series, and several commercially recognized M.7, M.26, M.9E, G.16, B.9 and O.3) was evaluated in two experiments and compared with the scion cultivar 'Delicious'/M.9. Direct inoculation of rootstock liners with *E. amylovora* using a syringe was made in a nursery and the length of the fire blight lesions was measured. All the 'V.' rootstocks were more resistant than M.26, with V.3, V.1 , V.6, V.7, V.2 having the greatest resistance, whilst in the second experiment, six rootstocks (M.7>V.6>V.3>V.1>V.2>V.4) were shown to be more resistant than M.26. The 'Delicious' scion displayed low resistance in both studies. These data indicate that the fire blight resistant responses could be grouped into the following four categories: high resistance (V.5, V.7), intermediate resistance (V.1, V.6, V.2, M.7, B.9), low resistance (G.16, V.3, M.9, V.4), and no resistance(M.26). The Vineland series of apple rootstock may afford greater resistance to fire blight infections than commercially available M.9 or M.26 rootstocks. Further research is required to determine how this resistance might be conferred to the scion, particularly for cultivars that have a high susceptibility to *E. amylovora*.

Introduction

Fire blight (caused by *Erwinia amylovora* (Burrill) Winslow et al.) is a serious disease affecting many Rosaceous tree species, particularly apples and pears. Rootstocks as well as scions are susceptible to this disease. Fire blight kills flowers and branches, and can lead to tree death if infection of primary scaffold limbs and rootstock occurs. Apple rootstocks of the Vineland series have been shown in empirical studies to be moderately resistant to fire blight. However, their resistance to direct inoculation under field conditions has not been determined.

The Vineland ('V.') series of apple rootstocks originated in 1958 as open-pollinated seedling hybrids of 'Kerr' crabapple (*Malus sylvestris* Mill) and M.9 rootstock at what was then the Horticultural Research Institute of Ontario (HRIO), Vineland Station, Ontario and is now the Dept. of Plant Agriculture, University of Guelph. The 'Kerr' crabapple was chosen as the maternal parent because of its exceptional winter hardiness, excellent rooting characteristics, and resistance to fire blight. Seven selections (V.1-V.7) were made based on desirable qualities including dwarf growth habit, cold hardiness, ease of propagation, and disease and insect resistance. In 1986, research plots of these rootstocks with various scion cultivars were established in Washington (2,3) and Ohio (8). After eight years of testing, the V. series rootstocks were more resistant to fire blight than M.26. Recent publications discuss the horticultural attributes of these rootstocks (4,6,7,9,10,11).

Industry interest in the Vineland rootstocks has been the primary impetus to assess their horticultural attributes as well as their disease resistance. The objective of the present study was to determine the re-

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sistance of the Vineland rootstocks to E. amylovora under field conditions following their direct inoculation.

Materials and Methods

Experiment One

Apple rootstocks (V.1, V.2, V.3, V.4, V.5, V.6, V.7, VR.50, M.7, M.26, O.3) supplied by the Horticultural Experiment Station, Simcoe and Dr. Aleck Hutchinson of HRIO, Vineland were established in a randomized planting at the AAFC Greenhouse and Processing Crops Research Centre, Harrow, Ontario (42° 02' N - 82° 54' W) in the spring of 1995. The soil was a Brookston Clay series (Aquaic Hapludalf) of mainly lucustrine clay with imperfect drainage. With the exception of V.5 of which only 5 trees were available, 10 single plants of each rootstock, ~ 6-8 mm diameter, and a fire blight resistant apple cultivar 'Delicious'/M.9 T337 (10-12 mm in diameter), were planted 0.5 m apart in rows, and ~1.5 m between rows. Rootstocks (treatments) were replicated and arranged in a randomized complete 10-block design given a total of 100 experimental plants of each rootstock or scion. Plants were grown without irrigation using standard nursery practices (1).

In early June 1996, during the period of rapid shoot growth prior to setting of terminal buds, three succulent shoot tips per plant were inoculated with 20μ of a standardized water suspension ($\approx 10^8$ cfu/ml water) of *E. amylovora* (strain E2017P) using a hypodermic syringe and 26-gauge needle (12). Five weeks after inoculation when lesions had ceased elongation, the number of infected shoots, length of infected shoot and total shoot length were recorded using procedures reported previously (5).

The progression of the fire blight infection from the point of inoculation basipetally through the shoot was recorded to the nearest 0.5 cm. The length of each inoculated shoot was also measured. Where the infection had spread beyond the shoot to the main stem, the full length of the shoot was recorded as infected. Following calculation of the proportion infected length of shoots, data were transformed using the arc-sine % function and analyzed by PROC GLM using SAS (Cary, NC) and separation of means was performed using Fishers' protected least significant difference. (P=0.05).

At the end of the growing season, inoculated shoots were removed by pruning the subtending wood, and the plants were held over into the next growing season. In early spring of 1997, 200 kg · ha^{-1} of N as ammonium nitrate was applied as a broadcast fertilizer to encourage plant growht. In June rootstocks were re-inoculated with *E. amylovora* and the deegree of infection measured using the procedures described above.

Experiment Two

In 1998, 6 mm diameter rootstock liners of M.26 EMLA, M.9 EMLA, G.16, B.9 and M.7 from a commerical nursery, 6 mm liners of V.1, V.1, V.3, V.4, V. 5, V.6 and V.7 from the Univesity of Guelph research nursery, and 'Delicious'/M.9 EMLA trees were planted with a 1.0 m in-row and 2.0 m between row spacing at the Agriculture and Agri-food Canada Research Farm in Delhi, Ontario (42° 52' N - 80° 33' W). The soil was a Brady sandy loam (Aquatic Hapludalf) of mainly lucrustrine sand and sandy loam with a pH of 6.4. Three liners of each rootstock were planted in a randomized complete block design with five replications. The trees were grown using standard nursery practices (1). Trickle irrigaton supplied ~ 25 mm of water per week, independent of rainfall. Insects, fungal diseases, and weeds were controlled by pesticides, fungicides, and hoeing respectively. In early June of 1998 and 1999, 200 kg · ha^{-1} N as ammonium nitrate was applied as a broadcast fertilizer to encourage plant growth. In June 1999, rootstocks were inoculated with *E. Amylovora* (Strain E2017P) and subsequently evaluated using the methods described in Experiment One.

Table 1. Relative susceptibility of shoots of apple rootstocks grown in heavy soil, to the extension of fire blight (*E. amylovora*) lesions in 1996 and 1997.

Rootstock	1996 Lesion length as percent shoot length	1997 Lesion length as percent shoot length
M.26	52.0 a[z]	98.6 ab[z]
VR.50	40.5 b	82.1 bc
V.5	40.1 b	100.0 a
O.3	na[y]	73.5 cd
V.4	14.5 c	49.3 ef
Delicious	12.5 c	62.8 de
V.2	11.4 c	48.8 ef
V.7	7.7 c	50.0 ef
M.7	7.7 c	42.4 f
V.6	7.2 c	47.5 ef
V.1	6.7 c	48.2 ef
V.3	6.3 c	48.1 ef
Significance[x]	***	***

[x] *** indicates significance at P=0.001
[y] na indicates data not available
[z] means in the same column followed by different letters differ significantly (P=0.05) using Fisher's Protected LSD.

Results & Discussion

In 1996 (Experiment 1), seven rootstocks and the cultivar 'Delicious' showed the following numerical sequence of decreasing fire blight resistance: V.3>V.1>V.6>M.7>V.7, V.1> 'Delicious'>V.4. These were statistically (P=0.05) more reisitant to shoot blight that VR.50 and V.5, all of which were more resistant that M.26 (Table 1). When the same rootstocks were re-inoculated in 1997, six rootstocks (M.7, V.6, V.3, V.1, V.2, V.4) were statistically (P=0.05) more resistant than M.26 and V.5. Rootstocks VR.50 and O.3 and scion 'Delicious' were intermediate in resistance.

In the 1999 test of 13 rootstocks (Experiment 2) there were large differences in rootstock resistance to fire blight. In general, fire blight resistant responses could be grouped into one of four arbitrary categories corresponding to the lesion length expressed as a percent of shoot length: high resistance (V.5, V.7, V.1, V.6, V.2), intermediate resistance (M.7, B.9, G.16, V.3), low resistance ('Delicious', M.9, V.4) and no resistance (M.26).

When the fire blight resistance of the common stocks among the two experiments is compared among the three sets of data, V.2, then M.7, V.6 and V.1 were most consistent in their resistance. V.3 was most resistant in 1996 and 1997, however only moderately resistant in 1999. V.4 consistently ranked moderate in resistance and V.5 was equal or less resistant than V.4. M.26, as anticipated, was consistently the least resistant rootstock evaluated. Two more recently introduced commercial rootstocks, B.9 and G.16 displayed moderate resistant in the 1999 test.

There is limited information available in the literature on rootstock resistance to fire blight. Treatment data are consisitent with those reported by Ferree *et al.* (8) after a severe natural infection of fire blight caused widespread tree loss in a rootstock trial. Tree mortality, averaged

Table 2. Ratings of induced fire blight infections (*E. amylovora*) following controlled shoot tip inoculation on rootstock susceptibility to blight. 1999 Delhi, Ontario.

Rootstock	Lesion length as percent shoot length
M.26	94.1 a[z]
V.4	74.9 b
M.9	70.0 bc
Delicious	69.1 bc
V.3	57.3 cd
G.16	52.7 de
B.9	43.3 def
M.7	42.9 efg
V.2	36.4 fgh
V.6	33.4 fgh
V.1	32.2 gh
V.7	29.5 h
V.5	26.0 h
Significance[y]	***

[z] means in the same column followed by different letters differ significantly (P=0.05) using Fisher's Protected LSD.
[y] *** indicates significance at P=0.001.

across three cultivars ('Macspur', 'Lawspur Rome Beauty' and 'Redchief Delicious'), was 0% on V.4 and V.7, 11% of V.1, 16% loss on V.2, and 31% on V.3, compared with 48% and 23% on M.26 EMLA and M.9 EMLA, repectively. While these data are not an actual determination of fire blight resistance, they do suggest that the Vineland rootstocks confer greater resistance to the scion than M.26 and are corroborated by the results of direct inoculation obtained in the present study.

Future research should concentrate on the performance of the V. series rootstocks in comparison with other commercial rootstocks such as M.9 EMLA, M.26 EMLA and B.9. In addition, the degree of fire blight resistance of the rootstock that is imparted to susceptible scion cultivars such as 'Royal Gala' should be examined further.

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